Home Mixing of Fertilizers And Straight Fertilizer Formulas

Published By
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STRAIGHT FERTILIZER FORMULAS

PUBLISHED BY

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Results from Use of Home Mixed Fertilizers on Wheat and on Rye.

Wheat—14 Bushels.	Wheat—37 Bushels.
Average Product per acre for the U. S. of Wheat with Average Farm Fertilization—1910.	The Product of an acre of Wheat Fertilized with Nitrate of Soda, Home Mixed with Phosphates and Potash—1910.

Rye—18 Bushels.	Rye—36 Bushels.
Average Product per acre for the U. S. of Rye with average Farm Fertilization—1910.	The Product of an acre of Rye Fertilized with Nitrate of Soda, Home Mixed with Phosphates and Potash—1910.

History of Home Mixing of Fertilizers in England and in Europe

The very interesting figures published by the United States Department of Agriculture not long since, showing the average yields per acre of wheat, oats and barley in the United States and in comparison with those of Germany, disclosed an extraordinary and humiliating condition here in America.

The average yields of wheat, oats and barley in Germany, covering a recent ten year period, is 28.4 bushels per acre for wheat; 47.3 bushels for oats; and 34.4 bushels for barley.

The United States shows an average yield for the same period of 14 bushels per acre for wheat; 30 bushels for oats; and 26 bushels for barley per acre, in round numbers.

In view of our soils being so much newer than those of Germany, and having been in use for comparatively few years, the early soil exhaustion of our lands compared with the splendid returns obtained in Germany, makes the comparison a very mortifying one for our American farmers.

If one looks at the history of the fertilizer business in this country, one may perceive some possible causes to account for these striking differences. The rational use of fertilizers has obtained in Germany from the time commercial fertilizers began to be used; that is to say, German farmers have always known Nitrate of Soda, acid phosphate and potash salts by their proper scientific names and their uses, because the Experiment Stations in Germany were organized in advance of the commercial fertilizer industry, and

taught the farmers from the very beginning the nature, composition and precise scientific use of them.

On the other hand, here in America, our Experiment Stations were not established until a false and irrational use of fertilizers had become firmly rooted among our farmers and planters; and even yet comparatively few of our American farmers know anything about the real nature of the several hundred compounds which are foisted upon them every year by fertilizer mixers. The constituents of these numerous compounds may comprise a group of certain chemicals this year, and a group of wholly different ones next year; and, as a rule, the printed matter in fertilizer manufacturers' booklets and on the fertilizer bags does not disclose anything whatever of the real nature and character or composition of the constituents of the contained fertilizers.

We have pure food laws which are now fairly effective. Our fertilizer laws curiously, however, are most defective in that they do not show anything as to the percentage of available Nitrogen; although they may occasionally show the percentage of available phosphoric acid and of available potash. The really important element in the fertilizer, both from a commercial as well as an agricultural food producing standpoint, is its Nitrogen.

Since the cheaper forms of Nitrogen are but imperfectly available, and, in fact, sometimes scarcely available at all,—and command in the open market several times the value of the best and most available forms of phosphoric acid and potash, our Experiment Stations would do an additional excellent work by prescribing an official analytical method for available Nitrogen fertilizers. We sincerely hope that they will continue to advocate Home Mixing and the use of straight fertilizers.

As long as valueless fillers are used, involving a high cost of freight on the filler material which the farmer must pay, and as long as the most inferior and

least available forms of Nitrogenous fertilizers receive the highest valuations by our Experiment Stations, just so long will our farmers be at a disadvantage in comparison with German farmers in producing maximum crops at minimum cost.

The use of fertilizers of the highest availability—in other words, the rational use of fertilizers, namely, the practical method used in Germany, is what we must come to here in order that our farmers may produce a larger quantity of food stuffs at a lower price. This, in turn, will react upon the general fertilizer business and cause a tremendously increased consumption of all the best forms of fertilizer materials, as is the case in Germany.

It seems extraordinary that our fertilizer industry refuses to get in line with modern progress, if only merely for the sake of its own prosperity.

The Home Mixing of Fertilizers

A hundred years ago the farmers of America and Europe had at their disposal but few materials for increasing the fertility of the land. Barnyard manure was then the great fertilizer, but only capable, as we realize now, of restoring but incompletely the plant-food carried away by the crops. Yet barnyard manure was justly esteemed for its fertilizing value, and on many a farm cattle were kept, not because they were in themselves profitable, but because of the manure that they produced. However, for all of the cattle kept on the farms of Europe, the productive power of its soils was declining. At this time the use of bones became prevalent and this marked the beginning of more rational methods of soil treatment.

The Rise of the Fertilizer Mixing Industry.

It was not until the second quarter of the nineteenth century, however, that new and important fertilizer materials came into the market. The increasing number of soil and crop analyses had demonstrated the invariable presence of the essential constituents in both soils and plants; while the numerous vegetation experiments showed that Nitrogen, phosphoric acid and potash were often present in the soil in amounts too small for profitable yields.

There then came into being a great fertilizer mixing industry. Peruvian guano held for a time a prominent place in the agriculture of contemporary Europe. It was not long, however, before the supply of the best grades of guano became depleted, though this did not occur until the chemist pointed the way to new treasures of plant-food. Nitrate of Soda, the most valuable source of commercial Nitrogen at present, came to play an increasingly important role after the middle of the nineteenth century. The potash salts of the German mines became a marketable commodity when the last

battles of our civil war were being fought; and when the great conflict was over, the phosphate deposits of South Carolina, and subsequently of Florida and Tennessee, were ready to supply the third important constituent of commercial fertilizers.

The Make-Up of Commercial Fertilizers.

The fertilizers sold to American farmers are valuable in so far as they contain the essential available constituents,—Nitrogen, Phosphoric Acid and Potash. When all are present the fertilizer is said to be *complete*, otherwise it is *incomplete*. It is the aim of the fertilizer mixers to supply to farmers both incomplete and complete fertilizers, chiefly the latter. Furthermore, usage and state legislation compel them to guarantee that their various brands contain a certain proportion of the essential constituents, but, unfortunately for the farmer, they do not require any disclosure whatever as to the availability of the most valuable content, viz., Nitrogen; hence, the attempt to state a *formula* on the bags, or on the tags attached to the latter, is a wholly incomplete affair. As an example, we may take a fertilizer whose formula is 4-8-10, that is, one containing 4 per cent. of Nitrogen, 8 per cent. of phosphoric acid and 10 per cent. of potash.

Materials of various qualities and grades are employed for the preparation of so-called complete fertilizers, as may be seen from the following list:

Materials Furnishing Nitrogen.	Materials Furnishing Phos. Acid.	MaterialsFurnishing Potash.
Nitrate of Soda Nitrate of Lime, Sulphate of Ammonia, Calcium Cyanamid, Dried Blood, Tankage, Fish Scrap, Cottonseed Meal, Horn and Hoof Meal, Hair and Wool, Leather Scrap.	Thomas Slag Acid Phosphate, Bone Meal, Phosphatic Guano, Fish Scrap, Bone Tankage.	Potash Salts (from Germany), Unleached Wood Ashes.

Aside from these materials, there are others that are occasionally employed by mixers to furnish filler.

Availability in Fertilizers.

In the making of complete goods from the various straight fertilizers the mixer is largely guided by the *cost*, as well as the *quality* of the latter. The question of quality is particularly important, since *no high grade fertilizer can be made from inferior ingredients.* The conception of quality has been gradually developed by investigators and farmers and the term *Availability* is commonly employed when the value of straight or mixed fertilizers is considered. We call a fertilizer Available when the Nitrogen, phosphoric acid or potash contained in it may be readily used by the crop; and not Available when it is transformed so slowly in the soil as to offer but little plant-food to the crop at any one time. A striking illustration of the significance of Availability in fertilizers is found in the action of comparatively small amounts of Nitrate on grass or grain applied early in the spring. It has been repeatedly observed that soils containing as much as .15 per cent. of Nitrogen, or 6,000 pounds per acre-foot out of a total of 2,000 tons, which such an acre-foot weighs, and capable of yielding about one ton of hay per acre, may be made to produce two tons of hay when top-dressed in the spring with only 100-150 pounds of Nitrate. At first it may seem strange that the 23 or 24 pounds of Nitrogen in 150 pounds of Nitrate of Soda should produce this magic effect, when measured against the 6,000 pounds of ordinary Nitrogen already in the soil. But the mystery is made clear to us when we remember that Nitrate of Soda is a soluble food that may be directly taken up by plant-roots, whereas the Nitrogen of the soil itself is nearly all locked up in inert humous compounds which must first pass through the various stages of Nitration before they become available. With some qualifications a similar comparison could be made between the phosphoric acid in ground phosphate rock, known as

"floats," and that in acid phosphate; or between potash in feldspar rock or clay and that in sulphate of potash.

In order to protect the farmer against fraud, fertilizer laws have been enacted in most of the Eastern States. These laws compel the mixers and dealers to *guarantee* their goods, that is, to state on the bags or tags how much Nitrogen, phosphoric acid and potash their fertilizers contain; furthermore, they are also compelled, but in an incomplete measure, to guarantee the quality, i. e., Availability, of the plant-food sold by them. The farmer is given, however, a fair measure of protection in so far as the phosphoric acid and potash purchased by him are concerned. He is told definitely how much phosphoric acid is present in available form. He knows, also, that the potash in mixed fertilizers is derived almost exclusively from the German potash salts, all of them readily available. On the other hand, he is given little protection in his purchase of Nitrogen. To be sure, the fertilizer laws compel the mixer to state *how much* Nitrogen there is present in this commodity; yet he is not compelled to tell the exact source or availability of the Nitrogen employed by him. From the consumer's standpoint this is a serious question, since a pound of Nitrogen costs about four times as much as a pound of either phosphoric acid or potash. If the law required merely the stating of the total per cent. of phosphoric acid or of potash without giving the amount of soluble or available percentages of the same, how incomplete the essential information would be as to the nature or value of the "so-called" complete fertilizers. More than that, the Nitrogen is not only costly but calls for greater farming skill in its use, lest the yields and quality of the produce be unfavorably affected. The Activity as well as the Availability of Nitrogen in materials like leather scrap, hair or peat is but one-fifth to one-tenth as much as that in Nitrate of Soda, and we can therefore realize the necessity of complete knowledge as to the agricultural use of Nitrogen.

It is conceded by all authorities that more accurate knowledge in this direction may be secured by the prac-

tice of *HOME-MIXING*, that is, by the purchase of the straight fertilizers and their mixing at home on the farm in amounts and proportions best suited for any particular soil and crop.

Barley

Pots manured with Phosphoric Acid, Potash and Nitrate of Soda.

Nitrate of Soda	none	1 gr.	2 gr.	3 gr.

In agricultural practice from 75 lbs. to 200 lbs. of Nitrate of Soda per acre is applied in one or more dressings.

Advantages of Home Mixing.

The practice of home-mixing has its friends as well as its opponents, but when all the arguments pro and con are summed up the decision must be entirely in its favor. The advantages claimed for *home-mixing* are:—

1. *Better adaptation to soil and crop.* Soils vary in their chemical composition, and in their previous history, as to cropping and fertilization. One soil may be deficient in available Nitrogen, another deficient in available phosphoric acid. In one instance a heavy application of manure, a crop of crimson clover, or alfalfa stubble may have been plowed under; and in a second instance a thin timothy sod. Evidently a crop of corn would not find the same amounts and proportions of food in these cases, and it is therefore idle to assume that a so-called corn fertilizer, whatever its composition, would prove as efficient in the one case as in the other.

Again, it is common knowledge that some crops are particularly grateful for applications of Nitrogen, while others are responsive to applications of phosphoric acid or of potash. Yet even here the soil and climate exert an important modifying influence. For instance, clovers and other legumes are capable of securing their Nitrogen from the air and, *except in the early stages of growth*, are independent of the supply in the soil or fertilizers. On the other hand, they require large amounts of potash, phosphoric acid and lime. Nevertheless, certain limestone soils require only applications of potash, while many silt loam or clay soils require only applications of phosphoric acid. In a word, then, no single formula for any particular crop can be devised to suit all soils and seasons. When the mixing is done on the farm, proper adjustment can be made to suit local conditions, known best by the farm manager after adequate experience.

One advantage of *Home*-Mixing is that the farmer may make any combination of plant-food he wishes, and know the form and availability of the ingredients of his own fertilizer, and he will save not only the high price paid for filler, but also the cost of transporting it.

2. *Better information concerning the quality of materials.* The present high prices of organic ammoniates are forcing the fertilizer mixers to employ various organic materials of inferior quality. Since the fertilizer laws do not require any distinction

Carrots

Pots manured with Phosphoric Acid, Potash and Nitrate of Soda

Nitrate of Soda	none	1½ gr.	3 gr.	4½ gr.

In agricultural practice from 2 cwt. to 4 cwt. of Nitrate of Soda per acre is applied in one or more dressings.

between the sources of Nitrogen, mixers feel free to meet competition and to reduce the cost of mixing by employing inert materials like leather-scrap, hair, wool and garbage tankage. Moreover, even the better grades of organic ammoniates like dried

blood, tankage, and ground fish are now adulterated more than formerly. *Home*-mixing protects the farmer against the use of inferior materials and permits him to purchase his Nitrogen in the readily available forms.

Many of the ingredients used by the manufacturers of "complete" fertilizers are produced directly or indirectly by themselves. Others, like Nitrate of Soda, potash salts and basic slag, are not produced in this country. Naturally the manufacturers will use as much as possible of the materials produced by themselves, on which they make both a raw material and a mixing profit, and spend as little as possible for imported materials on which they can make but one profit.

The "complete" fertilizer manufacturers use large quantities of low grade materials which the farmers would not buy for *Home*-Mixing because of the doubtful value of the Nitrogen owing to its not being available, that is, indigestible as plant food. But the manufacturer finds them doubly valuable as filler, because he can label his goods as containing so and so much Nitrogen, notwithstanding its indigestible quality as a plant food.

3. *Lower cost per unit of plant-food.* As shown by the analyses and valuations of fertilizers made by different experiment stations, the so-called *overhead* charges made by the mixers amount, on the average, to more than six dollars per ton. Otherwise stated, the farmer who buys mixed fertilizers is made to pay about six or seven dollars per ton for mixing, bagging, shipping, agents' commissions, profit, long credit, etc. The overhead charges tend to increase the cost per unit of plant-food in all fertilizers, and to a particularly marked extent in the cheaper brands. Home-mixing enables the farmer to secure available plant-food at a lower cost per unit.

4. *More profitable returns from the use of fertilizers may be secured when one understands their composition and the functions of their single ingredients.* The man who takes the trouble to make himself acquainted with the origin, the history and the action of different fertilizers is perforce bound to secure larger returns from them than the man who blindly follows the experience of others. For this reason the *home*-mixing of fertilizers is an educational factor of great importance. The farmer who does his own mixing is bound to observe the effect of season, of crop and of rotation. He is bound to learn something of the particular influences of Nitrogen, of phosphoric acid and of potash. In the course of time he is led to experiment for himself, with different mixtures, proportions and methods of application, and doing all these things he becomes more skilled and successful in the business of crop production.

The opponents of *home*-mixing have claimed, on their part, that the farmer cannot prepare mixtures as uniform as those made at the factory. They have also claimed that the mixtures made at the farm are more costly than similar mixtures made at the factory. As to the first of these objections, it has been demonstrated by most of the experiment stations in the East and the South that home-mixtures can be made mechanically as satisfactory as the best of the commercial brands. It is merely necessary to screen the single ingredients and to use some sort of a filler like dry peat or fine loam to prevent caking. The second objection is not at all borne out by the actual experience of farmers who have been using home-mixtures for years.

Equipment and Methods for Home-Mixing.

The equipment required for home-mixing is very simple and inexpensive. It consists of a screen with three (3) meshes to the inch, and about 4-5 feet long and 1½ to 2 feet wide, a shovel with square point, an iron rake, and platform scales.

The mixing may be done on a tight, clean barn floor, and a heavy wooden post is useful for crushing big lumps of the material; frequently the use of a sieve may be dispensed with by this means.

Previous to mixing, the materials are screened, the lumps broken up and again screened. The mixing may then be best accomplished by spreading out the most bulky constituent in a uniform layer about six inches thick. The next most bulky constituent is then similarly spread out on top of the first, and is followed in its turn by the others until the pile is complete. The several layers are then thoroughly mixed by shovelling the entire heap three or four times. Thorough mixing is shown by the absence of streaks of different materials. The mixture may be put in bags or other convenient receptacles and kept in a dry place until needed.

In mixing various materials some knowledge is required concerning the action of different ingredients upon each other. Such knowledge will prevent the danger of loss of constituents or the deterioration of quality. The materials that should not be employed together in mixed fertilizers are known as incompatibles. As is pointed out in this connection in Farmers' Bulletin No. 225, U. S. Department of Agriculture, it should be remembered that "(1) When certain materials are mixed chemical changes take place which result in loss of a valuable constituent, as when lime is mixed with guano, Nitrogen escapes; or in a change of a constituent to a less available form, as when lime is mixed with superphosphates, the phosphoric acid is made less soluble; and (2), mixtures of certain materials, as, for example, potash salts and Thomas Slag, are likely to harden or 'cake,' and thus become difficult to handle if kept some time after mixing."

Potash salts may be mixed with Thomas phosphate powder, but acid phosphate should not be mixed with quick lime, nor sulphate of ammonia with basic slag.

The modern farmer in America is beginning to understand the nature of straight fertilizers as well as

the farmer in Germany. He knows fairly well the character and qualities of the materials now used in mixing fertilizers; and can thus form his own judgment as to what is best for the different crops and soils.

It is better to spread fertilizers broadcast by hand, or by a top-dressing machine; fertilizer drills, as a rule, are not of sufficient capacity. Broadcasting is always a more thorough method of applying fertilizers, and gives the following crops a better opportunity to utilize all the material and prevents too much concentration of plant food by the plants. It also gives a better root development, since the plants are compelled to utilize a larger feeding area to no disadvantage, since it is nature's way.

It is generally better to harrow in fertilizers after they are applied, except on the seeded crops or on sod lands.

Calculations for Mixing Fertilizers.

As an example of how the proportions of the different ingredients in a mixture may be calculated, let it be assumed that a farmer wishes to prepare a 4-8-6 potato fertilizer out of Nitrate of Soda containing 15 per cent. of Nitrogen; acid phosphate containing 16 per cent. of available phosphoric acid and sulphate of potash containing 50 per cent. of actual potash. Remembering that each one hundred pounds of the required mixture is to contain 4 pounds of available Nitrogen, 8 pounds of available phosphoric acid and 6 pounds of available potash, we may best determine the amounts of each per ton by multiplying the given figures by 20. Thus:—

4 x 20 = 80 lbs. Available Nitrogen per ton.
8 x 20 = 160 " Available phosphoric acid per ton.
6 x 20 = 120 " Available potash per ton.

Hence each ton of the mixture is to contain 80 pounds of available Nitrogen, 160 pounds of available phosphoric acid and 120 pounds of available potash.

We next determine the amount of each ingredient necessary to furnish the required quantities of plant-food. Since each one hundred pounds of Nitrate contains 15 pounds of Nitrogen, the 80 pounds of Nitrogen required would represent as many hundreds or fractions thereof, as 15 is contained in 80; or

80 ÷ 15% =	533 lbs.	Nitrate of Soda
160 ÷ 16% =	1000 lbs.	Acid Phosphate
120 ÷ 50% =	240 lbs.	Sulphate of Potash
Filler......	227 lbs.	Fine dry loam, or peat, or land plaster (gypsum)
	2000 lbs.	

Calculations of Formula of Mixed Materials.

It is desirable, at times to determine the proportions of plant-food in any given mixture. For instance, a mixture is made up of 200 pounds of Nitrate of Soda, 200 pounds of tankage, 1,000 pounds of acid phosphate and 200 pounds of sulphate of potash, what is the formula if the Nitrate contains 15 per cent. of available Nitrogen, the tankage 5 per cent. of Nitrogen and 10 per cent. of phosphoric acid, the acid phosphate 16 per cent. of phosphoric acid, and the sulphate of potash 50 per cent. of potash. The amounts of plant food would then be:—

		Nitrogen lbs.	Phos. Acid lbs.	Potash lbs.
Nitrate of Soda..........	200 lbs. x .15 =	30	..	..
Tankage................	200 lbs. x .05 =	10	..	..
Tankage................	200 lbs. x .10 =	..	20	..
Acid Phosphate..........	1000 lbs. x .16 =	..	160	..
Sulphate of Potash.......	200 lbs. x .50 =	..	..	100
Total..................		40	180	100

A ton of the mixture would thus contain 40 pounds of Nitrogen, 180 pounds of phosphoric acid and 100 pounds of potash. To get the weight per hundred we divide each of these amounts by 20, obtaining a formula that may be represented by 2-9-5.

To Calculate the Value of Mixed Fertilizers.

When acid phosphate with 16 per cent. available phosphoric acid can be bought at $15.50 per ton; when sulphate of potash with 48 per cent. of potash is at $50.00 per ton, and when Nitrate of Soda containing 15 per cent. of Nitrogen, is at $52.00 per ton; what would be the value of a mixed fertilizer guaranteed to contain 6 per cent. of available phosphoric acid, 5 per cent. of potash, and 3.25 per cent. of Nitrogen?

As a preliminary step we have to determine the cost per pound of the constituents in the straight fertilizers. Thus:—

2000 lbs. of Nitrate of Soda x .15 = 300 lbs. available Nitrogen
$52.00 divided by 300 lbs. = $0.173 per lb.

2000 lbs. of Acid Phosphate x .16 = 320 lbs. Phosphoric Acid
$15.50 divided by 320 lbs. = $0.048 per lb.

2000 lbs. of Sulphate of Potash x .48 = 960 lbs. actual Potash
$50.00 divided by 1000 lbs. = $0.052 per lb.

Next comes the determination of the total plant-food in the mixed fertilizer. Thus:—

3.25%x2000 lbs. = 65 lbs. Nitrogen which at $0.173 per lb. =	$11.25
6.00%x2000 lbs. = 120 lbs. Phosphoric Acid which at .... 0.148 per lb. =	5.76
5.00%x2000 lbs. = 100 lbs. Potash which at 0.052 per lb. =	5.20
	$22.21

Assuming that all the Nitrogen in the mixed fertilizer was derived from Nitrate, the value per ton would be $22.21, exclusive of the cost of mixing and bagging.

Straight Fertilizer Formulas for Farm, Fruit, and Market Garden Crops.

The primary object in the preparation of fertilizer formulas is to show the kinds and amounts of materials to use in order to provide in a mixture good forms and proportions of the constituents, which shall be in good mechanical condition. It is not believed that any one formula is the *best* for all conditions, these vary as widely as the soils and different methods of management.

Substitutions That May Be Made.

It is not intended that the kinds of materials shall be absolutely adhered to, for in many cases substitutions of others may be made not only without materially changing the composition of the resultant mixture, but which may also reduce its actual cost. For example, tankage or dried ground fish may be substituted for cotton-seed meal in any mixture, and if the right grades are obtained, will substitute the amount of nitrogen in it, though it may be in a slightly less available form; besides, the former contains considerably more phosphoric acid. In other instances, dried blood may be substituted with advantage for the tankage or cotton-seed meal, though naturally one pound of high grade blood will furnish practically twice as much nitrogen as one pound of the others. Again, bone tankage, which is quite similar to ground bone in its composition, may be substituted for bone, and *vice versa*, the substitution depending upon the cost, as the availability of the constituents is not materially different. In the case of potash, the sulphate may be substituted for the muriate without changing the percentage of actual potash in the mixture; whereas if kainit is substituted for the higher grades, four times the weight must be included in order to obtain the same amount of potash, and the amount of

the mixture applied per acre must be doubled in order to obtain the same number of pounds of the constituents for a given area. For example, if in a mixture of

Nitrate of Soda	100 lbs.
Ground Bone	100 "
Sulphate of Potash	100 "

400 pounds of kainit is substituted for the 100 pounds of sulphate of potash, the percentage composition of the mixture would be just one-half the former, as the constituents are distributed throughout twice the weight.

Importance of Mechanical Condition.

In the next place, care should be exercised in the preparation of mixtures, in order to obtain good mechanical condition. It is sometimes a difficult matter to obtain a dry mixture from the use of purely mineral fertilizing materials, as superphosphates, and muriate of potash, or kainit—it is apt to become pasty in the drill or planter, whereas, if some dry material, as bone or tankage, is added, the mixture is much improved and the composition not materially affected.

The Kinds and Amounts to Apply.

It should also be remembered that the suggestions in reference both to the particular form of the constituents and the amounts to be applied have reference to their application under average conditions of soil and methods of practice, and as a supplement to the manures of the farm. Where a definite system of rotation is used, and the materials are applied with the purpose of providing the specific crop with the constituents especially needed, the formulas may be very materially changed. Where the condition of soil is not good, or where manures are not used, the amounts recommended should be largely increased, practically doubled in most cases, and also, particularly for the cereals, a greater proportion of nitrogen should be used. As a rule, soils that are not in good condition will require a larger application of fertilizers to obtain the same unit of increase than those in

good condition, because in the first case they do not permit the ready penetration of the roots and the easy distribution of the constituents. The indiscriminate use of fertilizers on poor soils is seldom followed by as large a return per unit of plant food applied as where systematic methods obtain.

Methods of Application.

The method of application should depend upon the character of the soil, the crop and the material. On good soils and for crops which require large quantities, a part at least, of the material should be applied broadcast and thoroughly worked into the surface-soil; the remainder may be used in the row at the time of seeding or setting the plants. It is particularly desirable that formulas that are rich in potash should be in part broadcasted, in order that this element may be thoroughly intermingled with the soil, as the rate at which this constituent fixes, particularly on soils of a clayey nature, is very rapid, and unless thoroughly harrowed in the fixing will take place largely at the surface, and thus not be within reach of the feeding roots. On sandy soils, and for such crops as sweet potatoes, the concentration of the fertilizer in the row is more desirable than in the case of good soils and for white potatoes, though the minerals phosphoric acid and potash may be distributed in part. When applied in the row for sweet potatoes, it is desirable that it should be done two or three weeks, at least, before the plants are set, thus avoiding possible injury from the excess in the soil.

Most manufacturers and dealers in fertilizers are willing to supply farmers with the materials suggested, or to mix them at reasonable rates.

If you cannot conveniently get all the materials for mixing your formulas and can secure any reputable brand of ordinary commercial fertilizer, buy a bag of Nitrate of Soda and mix it with four to six bags of such commercial fertilizer; and the mixing may be done on your barn floor. You will thereby improve and fortify the brand you are buying in a way to vastly enhance its crop-making powers.

If the Nitrate should happen to be lumpy, the use of a straight, heavy fence post, rolled over it two or three times will reduce it to splendid condition for home-mixing.

One hundred pounds of Nitrate of Soda is equal in bulk to about one bushel, or 25 pounds to about one peck.

Materials Not To Be Mixed.

Certain Ammoniates contain iron, and if mixed with acid phosphate you will lose a considerable portion of your available phosphoric acid.

Lime should not be mixed with Sulphate of Ammonia and materials containing lime, should not be used in this connection without advice from an experienced fertilizer chemist.

Excessive quantities of lime should not be mixed with Superphosphate, Barnyard Manure or Bone Meal.

Sulphate of Ammonia should not be mixed with Thomas Slag and Norwegian Nitrate.

Basic Slag should not be mixed with Sulphate of Ammonia, Blood or Tankage as the lime affects these materials and releases Ammonia. If mixed with Kainit it must be applied shortly after mixing.

Cyanamid must not be mixed directly with Sulphate of Ammonia, but if mixed according to directions will give good results.

Home-Mixing Table.

To ascertain the quantity of each material necessary to make 1,000 pounds of Fertilizer of any desired analysis.

Percentage Required.	Available Nitrogen from Nitrate of Soda.	Available Phosphoric Acid.		Available Potash from Sulphate of Potash.
		From 14% Acid Phosphate.	From 16% Acid Phosphate.	
1%	67 lbs.	71 lbs.	63 lbs.	19 lbs.
2%	133 "	143 "	125 "	38 "
3%	200 "	214 "	188 "	58 "
4%	267 "	286 "	250 "	77 "
5%	333 "	357 "	313 "	96 "
6%	400 "	429 "	375 "	115 "
7%	467 "	500 "	438 "	135 "
8%	533 "	571 "	500 "	154 "
9%	600 "	643 "	563 "	173 "
10%	667 "	714 "	625 "	192 "

Example: A common and profitable formula for Oats is 4-7-5, that is 4 per cent. Nitrogen, 7 per cent. phosphoric acid, 5 per cent. potash. From the table we ascertain that 4 per cent. available Nitrogen is obtained by using 267 pounds Nitrate of Soda, 7 per cent. available phosphoric acid is obtained by using 438 pounds 16 per cent. phosphate and 5 per cent. available potash is obtained by using 96 pounds sulphate of potash, making a total of 801 pounds which contains the same amount of plant food as 1,000 pounds of 4-7-5 ready-mixed fertilizer. Should it be desired to make an even thousands pounds, add a sufficient amount of fine dry loam.

Formulas for Farm Crops.

Corn.

(No. 1)

Nitrate of Soda	200 lbs.
Acid Phosphate	500 "
Sulphate of Potash	100 "
Fine Dry Loam	200 "
	1,000 lbs.

Application at the rate of 600 pounds per acre.

Composition:—Available Nitrogen 3.00 per cent.; available phosphoric acid 8.00 per cent.; available potash 5.00 per cent.

(No. 2)

Nitrate of Soda	150 lbs.
Acid Phosphate	500 "
Sulphate of Potash	100 "
Fine Dry Loam	250 "
	1,000 lbs.

Application at the rate of 600 pounds per acre.

Composition:—Available Nitrogen 2.25 per cent.; available phosphoric acid 8.00 per cent.; available potash 5.00 per cent.

Formula No. 1 is best suited for sandy loams or soils. Formula No. 2 is for medium and heavy loams.

Oats and Spring Wheat.

(No. 1)

Nitrate of Soda	250	lbs.
Acid Phosphate	450	"
Sulphate of Potash	100	"
Fine Dry Loam	200	"
	1,000	lbs.

Application at the rate of 400 pounds per acre.

Composition:—Available Nitrogen 3.75 per cent.; available phosphoric acid 7.20 per cent.; available potash 5.00 per cent.

(No. 2)

Nitrate of Soda	200	lbs.
Acid Phosphate	500	"
Sulphate of Potash	100	"
Fine Dry Loam	200	"
	1,000	lbs.

Application at the rate of 400 pounds per acre.

Composition:—Available Nitrogen 3.00 per cent.; available phosphoric acid 8.00 per cent.; available potash 5.00 per cent.

Formula No. 2 is best suited for use in connection with a leguminous green manure.

Winter Wheat, Rye and Hay or Grass Lands.

(No. 1)

Nitrate of Soda	100	lbs.
Acid Phosphate	600	"
Muriate of Potash	50	"
Fine Dry Loam	250	"
	1,000	lbs.

Application at the rate of 400 pounds per acre.

Composition:—Available Nitrogen 1.50 per cent.; available phosphoric acid 9.60 per cent.; available potash 2.50 per cent.

(No. 2)

Nitrate of Soda	200	lbs.
Acid Phosphate	500	"
Sulphate of Potash	100	"
Fine Dry Loam	200	"
	1,000	lbs.

Application at the rate of 400 pounds per acre.

Composition:—Available Nitrogen 3.00 per cent.; available phosphoric acid 8.00 per cent.; available potash 5.00 per cent.

Mixture No. 1 is best adapted for heavy soils; mixture No. 2, for medium and light loams.

Barley.

Nitrate of Soda	250	lbs.
Acid Phosphate	450	"
Sulphate of Potash	100	"
Fine Dry Loam	200	"
	1,000	lbs.

Application at the rate of 400 pounds per acre.

Composition:—Available Nitrogen 3.75 per cent.; available phosphoric acid 7.20 per cent.; available potash 5.00 per cent.

Clovers, Alfalfa, Cow Peas, Soy Beans and Vetch.

Nitrate of Soda	70	lbs.
Acid Phosphate	550	"
Sulphate of Potash	100	"
Fine Dry Loam	280	"
	1,000	lbs.

Application at the rate of 300–500 pounds per acre.

Composition:—Available Nitrogen 1.05 per cent.; available phosphoric acid 8.80 per cent.; available potash 5.00 per cent.

Cotton.

Nitrate of Soda	250 lbs.
Acid Phosphate	600 "
Sulphate of Potash	50 "
Fine Dry Loam	100 "
	1,000 lbs.

Application at the rate of 400 pounds per acre.

Composition:—Available Nitrogen 3.75 per cent.; available phosphoric acid 9.60 per cent.; available potash 2.50 per cent.

Rice.

Nitrate of Soda	100 lbs.
Acid Phosphate	800 "
Sulphate of Potash	100 "
	1,000 lbs.

Application at the rate of 300 pounds per acre. Apply soon after mixing.

Composition:—Available Nitrogen 1.50 per cent.; available phosphoric acid 12.80 per cent.; available potash 5.00 per cent.

Tobacco.

Nitrate of Soda	540 lbs.
Acid Phosphate	100 "
Sulphate of Potash	200 "
Fine Dry Loam	160 "
	1,000 lbs.

Application at the rate of 1,000 pounds per acre.

Composition:—Available Nitrogen 8.10 per cent.; available phosphoric acid 1.60 per cent.; available potash 10.00 per cent.

As a general rule, and subject to any special soil conditions, we recommend that the above Nitrate of Soda mixture intended to be applied to the tobacco crop be given in three equal dressings. The first of these should be incorporated with the soil just before the planting out, the second should be given

as a top dressing at the time of the first hoeing and the last instalment, in the same manner, about a fortnight or three weeks later.

Sweet Potatoes.

Nitrate of Soda........................	200 lbs.
Acid Phosphate........................	550 "
Sulphate of Potash....................	150 "
Fine Dry Loam........................	100 "
	1,000 lbs.

Application at the rate of 1,000 pounds per acre.

Composition:—Available Nitrogen 3.00 per cent.; available phosphoric acid 8.80 per cent.; available potash 7.50 per cent.

Early and Late Irish Potatoes.

(No. 1)

Nitrate of Soda........................	320 lbs.
Acid Phosphate........................	480 "
Sulphate of Potash....................	100 "
Fine Dry Loam........................	100 "
	1,000 lbs.

Application at the rate of 1,000 pounds per acre.

Composition:—Available Nitrogen 4.80 per cent.; available phosphoric acid 7.68 per cent.; available potash 5.00 per cent.

In order to secure a satisfactory mechanical condition, this mixture will require about 300-400 pounds additional of fine dry loam for each 1,000 pounds of material.

(No. 2)

Nitrate of Soda........................	260 lbs.
Acid Phosphate........................	440 "
Sulphate of Potash....................	100 "
Fine Dry Loam........................	200 "
	1,000 lbs.

Application at the rate of 1,000 pounds per acre.

Composition:—Available Nitrogen 3.90 per cent.; available phosphoric acid 7.00 per cent.; available potash 5.00 per cent.

Hops.

Nitrate of Soda	600 lbs.
Acid Phosphate	200 "
Sulphate of potash	100 "
Filler	100 "
	1,000 lbs.

Application at the rate of 1,000 pounds per acre.

Composition:—Available Nitrogen 9.00 per cent.; available phosphoric acid 3.20 per cent.; available potash 5.00 per cent.

Formula for Market Garden Crops

Asparagus, Beans, Beets, (early), Cabbage, Carrots, Cauliflower, Celery, Cucumbers, Egg-Plant, Endive, Kale, Lettuce, Muskmelons, Onions, Peas, (early), Peppers, Pumpkins, Radishes, Spinach, Squash, Tomatoes and Watermelons.

Nitrate of Soda	300 lbs.
Acid Phosphate	400 "
Sulphate of Potash	100 "
Fine Dry Loam	200 "
	1,000 lbs.

Application at the rate of about 1,000 pounds per acre, at the time of seeding and an additional application at the rate of about 500 pounds to be made between the rows later in the season.

Composition:—Available Nitrogen 4.50 per cent.; available phosphoric acid 6.40 per cent.; available potash 5.00 per cent.

Formulas for Fruits and Berries

Apples, Pears, Peaches, Plums, Grapes, Currants, Strawberries, Raspberries, Blackberries, and Gooseberries.

(No. 1)

Nitrate of Soda	300 lbs.
Acid Phosphate	400 "
Sulphate of Potash	100 "
Fine Dry Loam	200 "
	1,000 lbs.

Applications at the rate of about 1,000 pounds per acre for berries and 400-800 pounds for fruit trees.

Composition:—Available Nitrogen 4.50 per cent.; available phosphoric acid 6.40 per cent.; available potash 5.00 per cent.

(No. 2)

Nitrate of Soda	200 lbs.
Acid Phosphate	300 "
Sulphate of Potash	100 "
Fine Dry Loam	400 "
	1,000 lbs.

Application at the rate of about 1,000 pounds per acre for berries and 400-800 pounds for fruit trees.

Composition:—Available Nitrogen 3.00 per cent.; available phosphoric acid 4.80 per cent.; available potash 5.00 per cent.

Formula 1 is best adapted for medium and heavy soils, Formula 2 for sandy soils.

Formulas for Citrus Fruits

Young Orange Trees

Nitrate of Soda	350	lbs.
Acid Phosphate	350	"
Sulphate of Potash	100	"
Fine Dry Loam	200	"
	1,000	lbs.

Application at the rate of 1,000 pounds per acre.

Composition:—Available Nitrogen 5.25 per cent.; available phosphoric acid 5.60 per cent.; available potash 5.00 per cent.

Old Orange Trees.

Nitrate of Soda	375	lbs.
Acid Phosphate	435	"
Sulphate of Potash	90	"
Fine Dry Loam	100	"
	1,000	lbs.

Application at the rate of 1,600 pounds per acre.

Composition:—Available Nitrogen 5.62 per cent.; available phosphoric acid 7.96 per cent.; available potash 4.50 per cent.

Mandarin Oranges.

Nitrate of Soda	375	lbs.
Acid Phosphate	420	"
Sulphate of Potash	80	"
Fine Dry Loam	125	"
	1,000	lbs.

Application at the rate of 1,200 pounds to the acre.

Composition:—Available Nitrogen 5.62 per cent.; available phosphoric acid 6.72 per cent.; available potash 4.00 per cent.

Grape Fruit.

Nitrate of Soda	375 lbs.
Acid Phosphate	435 "
Sulphate of Potash	90 "
Fine Dry Loam	100 "
	1,000 lbs.

Application at the rate of 1,800 pounds per acre.

Composition:—Available Nitrogen 5.62 per cent.; available phosphoric acid 7.96 per cent.; available potash 4.50 per cent.

Lemons.

Nitrate of Soda	375 lbs.
Acid Phosphate	435 "
Sulphate of Potash	90 "
Fine Dry Loam	100 "
	1,000 lbs.

Application at the rate of 1,600 pounds per acre.

Composition:—Available Nitrogen 5.62 per cent.; available phosphoric acid 7.96 per cent.; available potash 4.50 per cent.

Formulas for Olives.

Young Olive Trees.

Nitrate of Soda	300 lbs.
Acid Phosphate	450 "
Sulphate of Potash	150 "
Fine Dry Loam	100 "
	1,000 lbs.

Application at the rate of 660 pounds per acre.

Composition:—Available Nitrogen 4.50 per cent.; available phosphoric acid 7.20 per cent.; available potash 7.50 per cent.

Old Olive Trees.

Nitrate of Soda	260 lbs.
Acid Phosphate	520 "
Sulphate of Potash	85 "
Fine Dry Loam	135 "
	1,000 lbs.

Application at the rate of 1,150 pounds per acre.

Composition:—Available Nitrogen 3.90 per cent.; available phosphoric acid 8.32 per cent.; available potash 4.25 per cent.

GENERAL DIRECTIONS FOR THE USE OF NITRATE OF SODA ON STAPLE CROPS.

We never recommend the use of Nitrate of Soda alone except at the rate of one hundred pounds to the acre, for seeded crops and two hundred pounds to the acre for cultivated crops. It may be thus safely and profitably used without other fertilizers. It may be evenly applied at this rate as a broadcast top-dressing, by hand, or by machine, in the Spring of the year, as soon as crops begin rapid, new growth. At this rate very satisfactory results are usually obtained without the use of any other fertilizer, and soda residual, after the nitrogenous food of this chemical is used up by the plant, has a perceptible effect in sweetening sour land. One hundred pounds of Nitrate is equal in bulk to about one bushel.

When it is desired to use a larger amount than one hundred pounds of Nitrate per acre for seeded crops (or two hundred pounds per acre for cultivated crops) there should be present some form of available phosphatic and potassic plant food, and we recommend two hundred pounds of acid phosphate and one hundred pounds of sulphate of potash.

In most of our Grass experiments where Nitrate was used alone at the rate of only one hundred pounds per acre, not only was the aftermath, or rowen much improved, but in subsequent seasons, with no further application of fertilizers to the plots a decidedly marked effect was noticed, even on old meadows. This speaks very well indeed for Nitrate of Soda not leaching out of the soil. The readily soluble elements of fertility are the readily available elements. The natural capillarity of soils, doubtless, is in most instances a powerful factor in retaining all readily soluble elements of fertility, otherwise all the fertility of the world in our humid regions would, in a season or two, run into the ocean, and be permanently lost. This is mentioned on account of certain critics having taken the trouble to object to

the use of Nitrate on the ground that it would leach away. A case is yet to be seen where the after effects of Nitrate are not distinguishable, and in most cases such effects have been marked. The two thousand tons of active top soil in an acre of land have a powerful holding capacity for all the useful available elements of fertility. These 2,000 tons form the part usually subject to cultivation and might be called service soil.

For market gardening crops, hops, sugar-beets and other cultivated crops, two hundred pounds of Nitrate per acre may be used to great advantage.

When the above amounts of phosphatic and potassic fertilizers are used, as much as two hundred and fifty pounds of Nitrate, or even more, may be applied with profit.

If you have any reason to suspect adulteration of Nitrate, send a pound or so of it to your Experiment Station for analysis, giving date of purchase, full name and address of dealer and of the company which the seller represents, with full description of marks on the bag or bags from which you draw the sample.

On the Pacific Coast, Nitrate may be applied as a top-dressing after the heavy Spring rains are over, but before crops attain much of a start; although recent experience in California suggests that Nitrate may be applied to better advantage just as soon as growth starts in the Spring, or better, before seeding or planting.

When Nitrate is applied at the rate of two hundred (200) pounds per acre for cultivated crops and used alone this application figures out at the rate of 8 oz. for a plot 10x10. This application is equivalent to about 1 oz. to the square yard.

So many inquiries have been made requesting amounts to be applied to small areas that the above word is given in this connection.